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NEMATODES OF LAKE BALATON. IV. SEASONAL QUALITATIVE AND QUANTITATIVE CHANGES

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Nematodes are difficult to study. Only a few researches work on them in our country although these animals gain an increasing significance today. The members of this group counting several ten-thousands of species are partly human parasites, partly animal and plant parasites causing severe damages, while another part they are free-living and contribute to the mineralization of organic substances. Their individual number can be very high, e.g. in 1 hectare of forest soil it may reach 70 thousand millions per year, their total weight amounts to 90 kg, although the majority of those species weigh a mere few tenths of microgram. They play a very important role in the sediments of clean waters, in the purification of sewage-waters, e.g. in the dropping bodies and even in the life of the waste-stabilization ponds.

The nematodes living in the sediment of Lake Balaton have been studied by DADAY (1897), BIRÓ (1968; 1969; 1972), BIRÓ et al. (1968), PONYI et al. (1971), whereas those living in the coating of reed have been described by MESCHKAT (1934).

The "Research of Balaton" program of the Biological Research Institute of Tihany gave an opportunity for the present series of investigation. The work was intended at establishing the quantitative seasonal changes of Nematoda fauna.

Places of samplings, material and methods

Samplings were carried out from three points of each five transversal sections of Lake Balaton once a month *(Fig. 1)* from April till November during 1966–1968, as well as from under the ice in January and February from the point of sampling in front of Tihany (point "A_0") in 1968. The places of sampling were as follows:

"M" section: between Gyenesdiás and the mouth of river Zala.
"K" section: between Szigliget and Balatonmária.
"G" section: between Balatonakali and Balatonszemes.
"A" section: between Balatonfüred and Zamárdi (Tihany).
"E" section: Balatonalmádi–Balatonvilágos line.

Some data concerning the collections are summarized in *Table I*. The temperature data refer to the water. Samples from the soft bottom were collected by the modified Craib's bottom-dredge (PONYI et al., 1967) from under

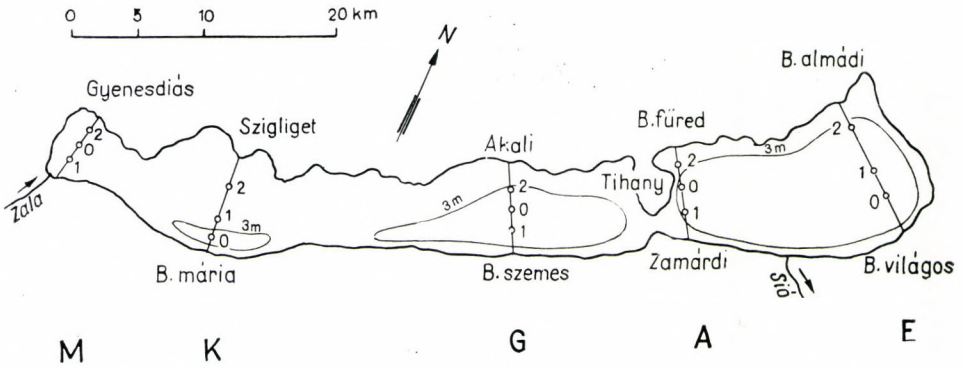

Fig. 1. The collecting places. "M", "K", "G", "A" and "E" indicate the sections, 0, 1 and 2 the points of sampling. The sign 0 indicates the deepest point of the sections

TABLE I

Data of water temperatures and depths

Places of samplings Date	M_0		K_0		G_0		A_0		E_0	
	cm	°C	cm	°C	cm	°C	cm	°C	cm	°C
1966 V	275	19	368	19	428	19	368	20	480	20
VI	292	23	419	23	443	23	410	22	410	22
VII	300	19	400	20	420	20	395	21	445	22
VIII	285	22	420	22	440	23	360	22	450	22
IX	271	17	298	17	421	19	398	18	460	18
X	280	16	385	16	420	16	380	17	420	17
XI	264	4	378	6	420	6	380	6	460	6
1967 IV	276	12	375	12	423	11	372	12	450	12
V	268	19	405	19	430	19	410	19	457	19
VI	271	20	390	19	405	20	385	24	441	25
VII	268	20	370	22	410	22	359	24	457	23
VIII	244	20	367	20	410	21	370	21	432	21
IX	255	16	369	17	392	18	400	17	418	18
X	266	16	370	16	397	17	373	13	420	14
XI							353	2	354	2
1968 I							375	0.2*		
II							383	0.7*		
IV	264	14	378	14	395	13	435	11	380	12
V	269	16	368	15	388	15	380	18	428	17
VI	272	20	372	20	395	20	385	20	432	20
VII	269	21	364	21	375	21	353	21	416	21
VIII	261	20	351	20	367	20	345	20	400	20
IX	257	18	346	18	366	18	352	18	394	18
X	255	15	355	15	370	15	372	16	382	16
XI	288	8	375	8	390	8	378	7	392	8

* thickness of the ice 25 cm

water in 240—480 cm depth. Each sample was about 3 cm thick and was taken from a surface of 13 cm^2. Three parallel samples were united at each place and fixed in formalin. The separated nematodes were investigated in glycerinized preparations. The calculation of the biomass was carried out by using the method of ANDRÁSSY (1956).

Occurrence of species at different regions

About 20 thousand of individuals belonging to 31 species were collected. The frequent nematodes were found everywhere in the mud of the lake *(Paraplectonema pedunculatum* S., *Paraphanolaimus behningi* M., *Ironus tenuicaudatus* dM., *Theristus setosus* B., *Monhystera paludicola* dM.). From the species of rarer occurrence *Hemicycliophora aquatica*, *Prismatolaimus dolichurus*, *Plectus tenuis* were encountered only in the north-eastern basin, whereas *Chromadorina bercziki*, *Neochromadora izhorica* and *Punctodora dudichi* were collected only in the south-west *Monhystera stagnalis* and *Tripyla papillata* were also more frequent in the south-western basin, however, one specimen of each was found in the other basin, too.

Table II lists the species found in Lake Balaton and compared to the data of DADAY (1897). Some of the species described by the latter author proved to be synonyms as well as uncertain species, therefore, only 26 of his list of species could be identified with certainty. The present paper uses the nomenclature of ANDRÁSSY (1972).

In the fauna of Hungary and Lake Balaton, *Paraphanolaimus anisitsi* (DADAY, 1905; ANDRÁSSY, 1968) is of rare occurrence. During the recent years it was recovered from Paraguay (ANDRÁSSY, 1968), Columbia (RIEMANN, 1971) and in Europe from the Lake Leman (JUGET, 1969), and Lake Balaton (BIRÓ, 1972). Although the specimen found by JUGET was identified to be *Paraphanolaimus behningi* MIC. 1923, on the basis of his drawing and description it is *Paraphanolaimus anisitsi* (D.) A. A male *Paraphanolaimus behningi* M. was found in Lake Balaton (BIRÓ, 1968) and also in the Soviet-Union (GAGARIN, 1970). It can well be observed on this species that the spiculum is thin and its length is about 4—5 times larger than the anal width of the body, whereas in the case of *P. anisitsi* the spiculum is bulky and its length hardly reaches one and a half times the anal width of the body *(Figs. 2* and *3)*.

Paraplectonema pedunculatum (H.) S. *(Fig. 4)* occurs sporadically in Europe. However, in the open water sediment of Lake Balaton and Lake Fertő it is (SCHIEMER et al. 1969) the most frequent Nematoda. This species seems to prefer the detritus-rich mud-layers of 2—5 cm thickness under the shallow waters of pH 8.3.

The quantity of nematodes

Among the nematodes found during 1966—68, the most frequent species was *Paraplectonema pedunculatum:*

Paraplectonema pedunculatum S.	20.3%
Paraphanolaimus behningi M.	20.0%
Ironus tenuicaudatus dM.	18.9%
Theristus setosus M.	16.6%
Monhystera paludicola dM.	15.1%
Other 26 species	9.1%

TABLE II

The distribution of nematodes found in the five sections of Lake Balaton during 1966—68

	1897 Daday	1966—68					%
		M	K	G	A	E	
Achromadora terricola (dM.) M.		+		+	+		0.02
Acrobeloides emarginatus (dM.) T.	+						
Aphanolaimus aquaticus D.	+		+	+	+	+	2.13
Aporcelaimellus obtusicaudatus (B.) A.	+						
Campydora balatonica (D.) A.	+						
Chromadorina bercziki A.		+					0.04
Chromadorina bioculata (S.) W.	+						
Diplogaster rivalis (L.) B.	+						
Dorylaimus helveticus (S.) A.				+	+		0.09
Dorylaimus stagnalis D.	+	+		+	+	+	0.11
Ethmolaimus pratensis dM.			+	+	+	+	0.84
Eudorylaimus bryophilus (dM.) A.	+						
Hemicycliophpora aquatica (M.) L.					+	+	0.04
Heterocephalobus elongatus (dM.) A.	+						
Ironus colourus S.		+				+	0.02
Ironus tenuicaudatus DM.	+	+	+	+	+	+	18.94
Laimydorus flavomaculatus (L.) S.	+						
Mesodorylaimus bastiani (B.) A.	+						
Mermis sp.	+			+	+	+	0.03
Microlaimus globiceps dM.				+	+		0.02
Monhystera andrassyi B.		+	+	+	+	+	0.14
Monhystera dispar B.				+			0.01
Monhystera gerlachi M.		+					0.02
Monhystera macramphis F.		+	+	+	+	+	0.33
Monhystera paludicola dM.		+	+	+	+	+	15.10
Monhystera stagnalis B.	+	+	+	+	+	+	0.19
Monhystera vulgaris dM.			+	+			0.02
Mononchus truncatus B.	+						
Neochromadora izhorica (F.) S.		+					0.12
Paractinolaimus macrolaimus (dM.) A.	+						
Paradorylaimus filiformis (B.) A.	+						
Paraphanolaimus anisitsi (D.) A.		+	+	+	+	+	0.82
Paraphanolaimus behningi M.		+	+	+	+	+	20.06
Paraplectonema pedunculatum (H.) S.		+	+	+	+	+	20 30
Plectus cirratus B.	+						
Plectus parvus B.	+						
Plectus tenuis B.	+				+		0.01
Prismatolaimus dolichurus dM.	+				+	+	0.04
Punctodora dudichi A.		+					0.02
Punctodora ratzeburgensis (L.) F.	+			+		+	0.06
Theristus setosus (B.) M.	+	+	+	+	+	+	16.60
Tobrilus gracilis (B.) A.	+	+	+	+	+	+	3.32
Tobrilus helveticus (H.) A.			+	+	+	+	0.22
Tobrilus longus (L.) A.					+		0.04
Tobrilus pellucidus (B.) A.	+						
Tripyla glomerans B.	+	+	+	+	+	+	0.30

Note: the percentage indicates the properties as compared to the total number of individuals encountered. "M", "K", "G", "A" and "E" are the places of collecting.

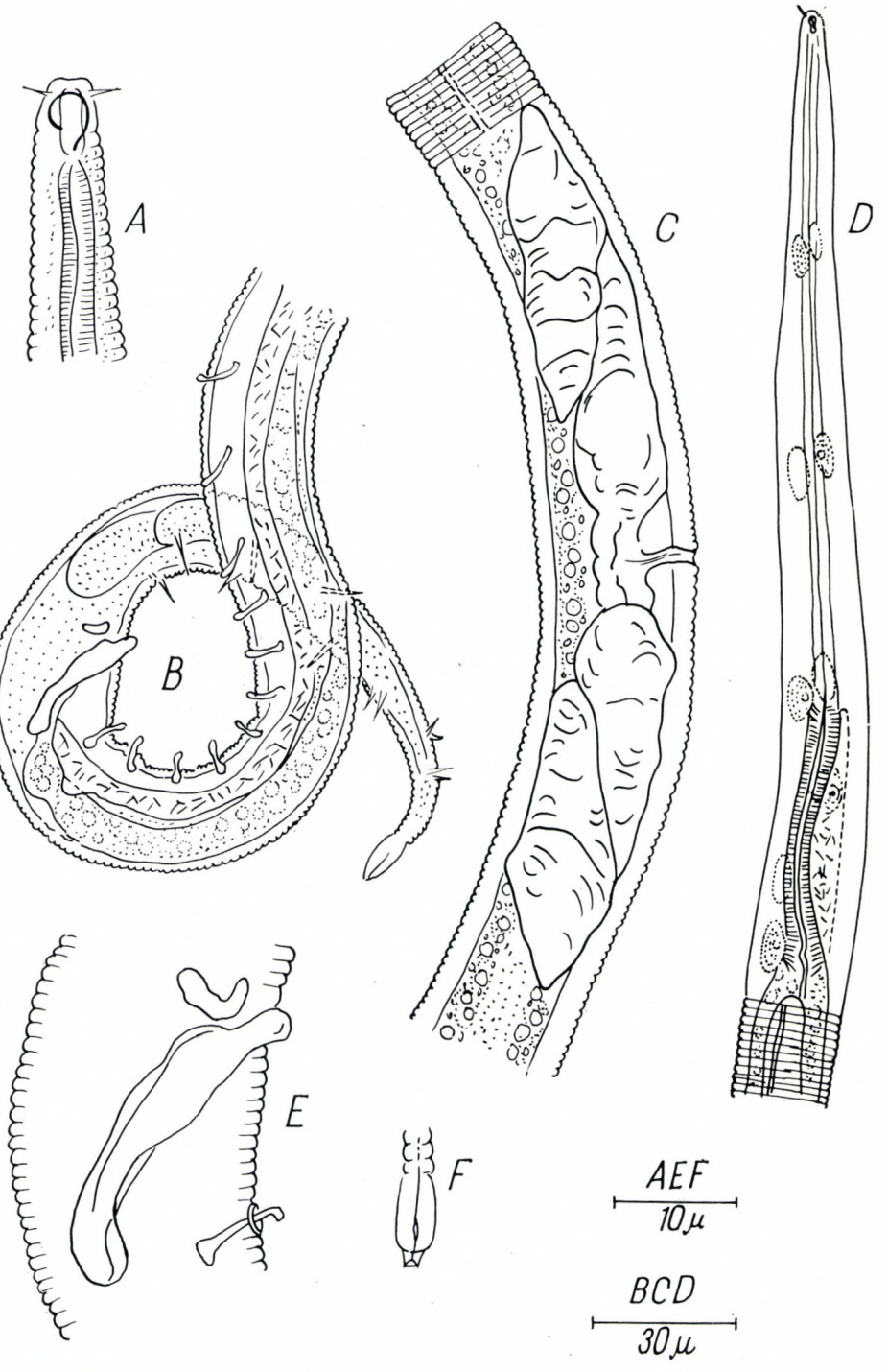

Fig. 2. Paraphanolaimus anisitsi (Daday, 1905) Andrássy, 1968. A = oral end of the animal; b = caudal end of the animal; C = female genital organs; D = oral part of the animal with the oesophagus; E = spiculum; gubernaculum and one of the preanal papillae; F = caudal end

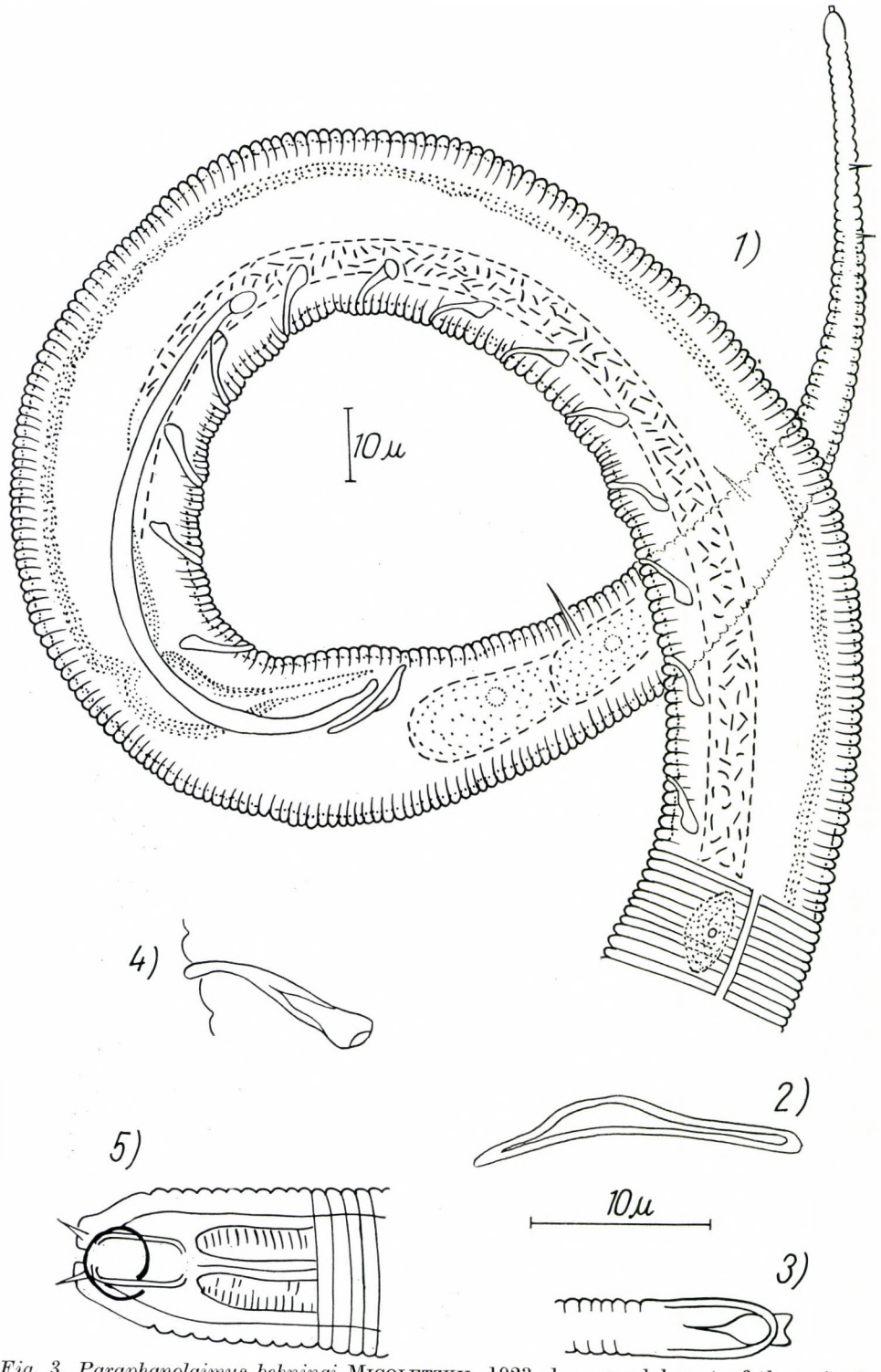

Fig. 3. Paraphanolaimus behningi Micoletzky, 1923. 1 — caudal part of the animal; 2 — gubernaculum; 3 — caudal end; 4 — preanal papilla; 5 — oral end of the animal

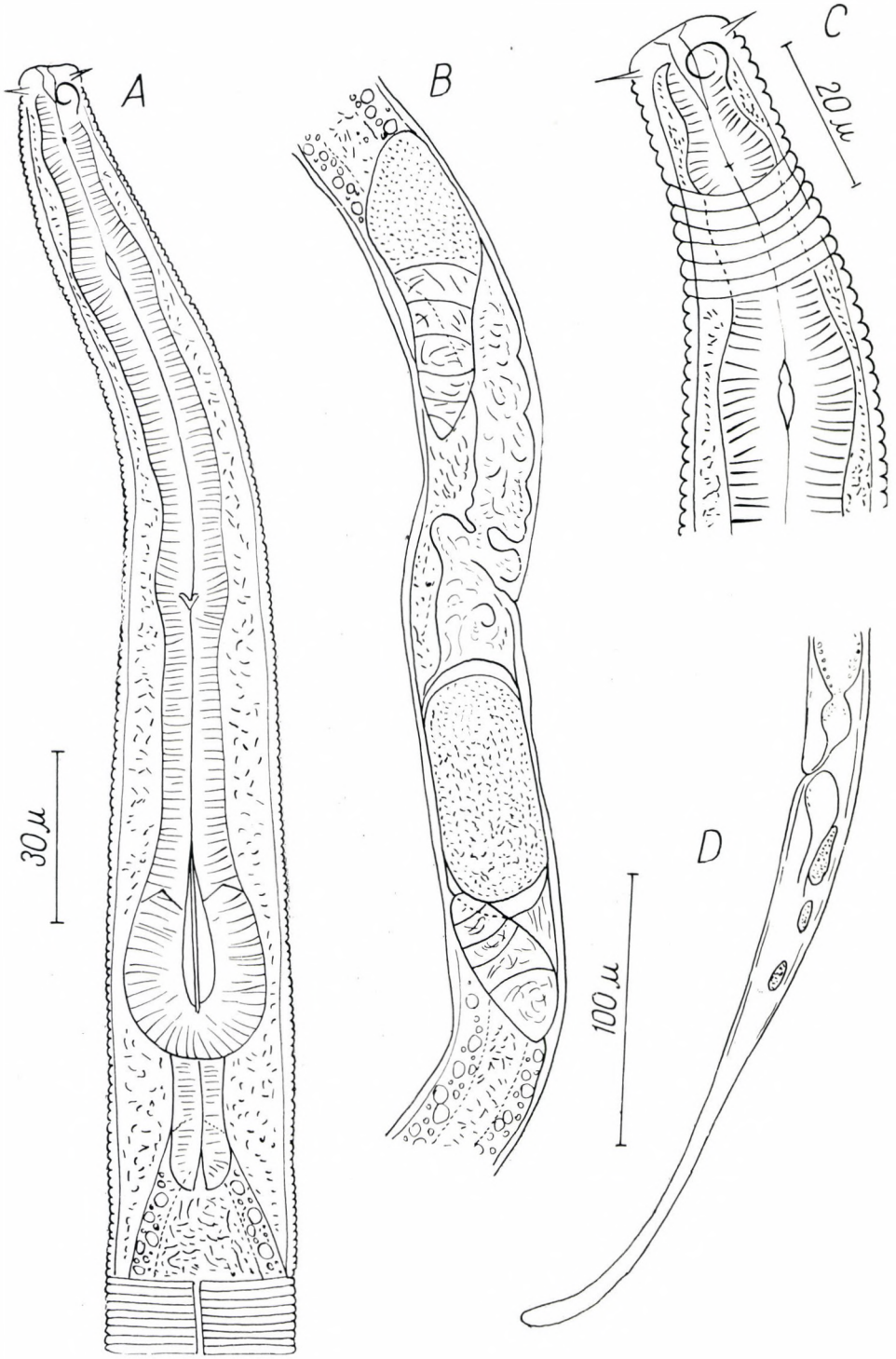

Fig. 4. Paraplectonema pedunculatum (Hofmänner, 1913) Strand, 1934. A = anterior part of the animal with the oesophagus; B = female genital organs; C = oral end of the animal; D = caudal end of the body

A seasonal change was observed in the proportions of species. When the water temperature was below 12 °C, the proportions of species were different from those of the warmer periods:

	Periods	
	"cold" below 12°C	"warm" above 12°C
Paraplectonema pedunculatum S.	13.7%	25.8%
Paraphanolaimus behningi M.	6.7%	24.2%
Ironus tenuicaudatus dM.	17.1%	19.4%
Theristus setosus M.	32.1%	11.6%
Monhystera paludicola dM.	20.4%	10.7%
Other nematodes	10.0%	8.3%

An almost identical order of magnitude of frequency was observed in cases of fine species during three years in average (20, 20, 17, 19, 15 percent). During the cold periods, *Theristus setosus* and *Monhystera paludicola* (32 and 20 percent), during summer, *Paraplectonema pedunculatum, Paraphanolaimus behningi* and *Ironus tenuicaudatus* (25, 24 and 20 percent) predominated. During the winter season under the ice, as high as 60 percent of frequency of *Theristus setosus* was observed in the section between Zamárdi and Balatonfüred ("A_0"). *Tobrilus* species could hardly be collected in other periods of the year, nevertheless under the ice they reached even 15—20 percent of the total number of individuals.

The distribution of nematodes was not uniform at different regions of Lake Balaton. Considering the monthly averages Balatonszemes—Balatonakali ("G") was the richest section and the poorest was that of the Keszthely Bay ("M" section) *(Fig. 5)*. According to the findings, the number of nematodes was lower on identical surfaces during the summer, than during the cold season i.e. in winter it amounted only to 60—75 percent of the latter. Evaluating the collections of the past three years, one can state that the lowest number of nematodes occurs in late summer (10—15 000 individuals per m^2). As against to the other places of collection, in the Keszthely Bay the lowest number of individuals was found in early summer (10 000 i/m^2), whereas by the end of summer *Paraplectonema pedunculatum* propagated so profusely that the highest number of nematodes was found there (50 000 i/m^2). The highest number of nematodes was found during the spring season at the other regions of the south-western basin ("K" and "G") as well as in the north eastern one "A" and "E"), reaching 60—80 000 i/m^2 *(Fig. 5)*.

The Keszthely-Bay is the poorest in nematodes ("M") among all the areas of the lake. The average number of individuals was 19 000 i/m^2 in 1966 and 1967, however in 1968 it reached 35 000 i/m^2. During all the three years the lowest number (10 000 i/m^2) was found in July and the highest one (40—60 000 i/m^2) in August (first column of *Fig. 5)*. The summer increase was caused by the quick propagation of *Paraplectonema pedunculatum*. Of the five species of highest frequency occurring everywhere, the highest number of *Theristus setosus* was encountered during the cold period, that *Ironus tenuicaudatus* and *Paraplectonema pedunculatum* during the warm period.

Several species were found toke absent in other regions of the lake: *Chromadorina bercziki, Monhystera gerlachi, Neochromadora izhorica, Punctodora dudichi*. The last but one is known from the delta of river Neva, i.e. from a slowly flowing water, while the first and last are known from the mud of River Danube, i.e. also from a flowing water. Their presence can perhaps be explained by the vicinity and effect of the river Zala.

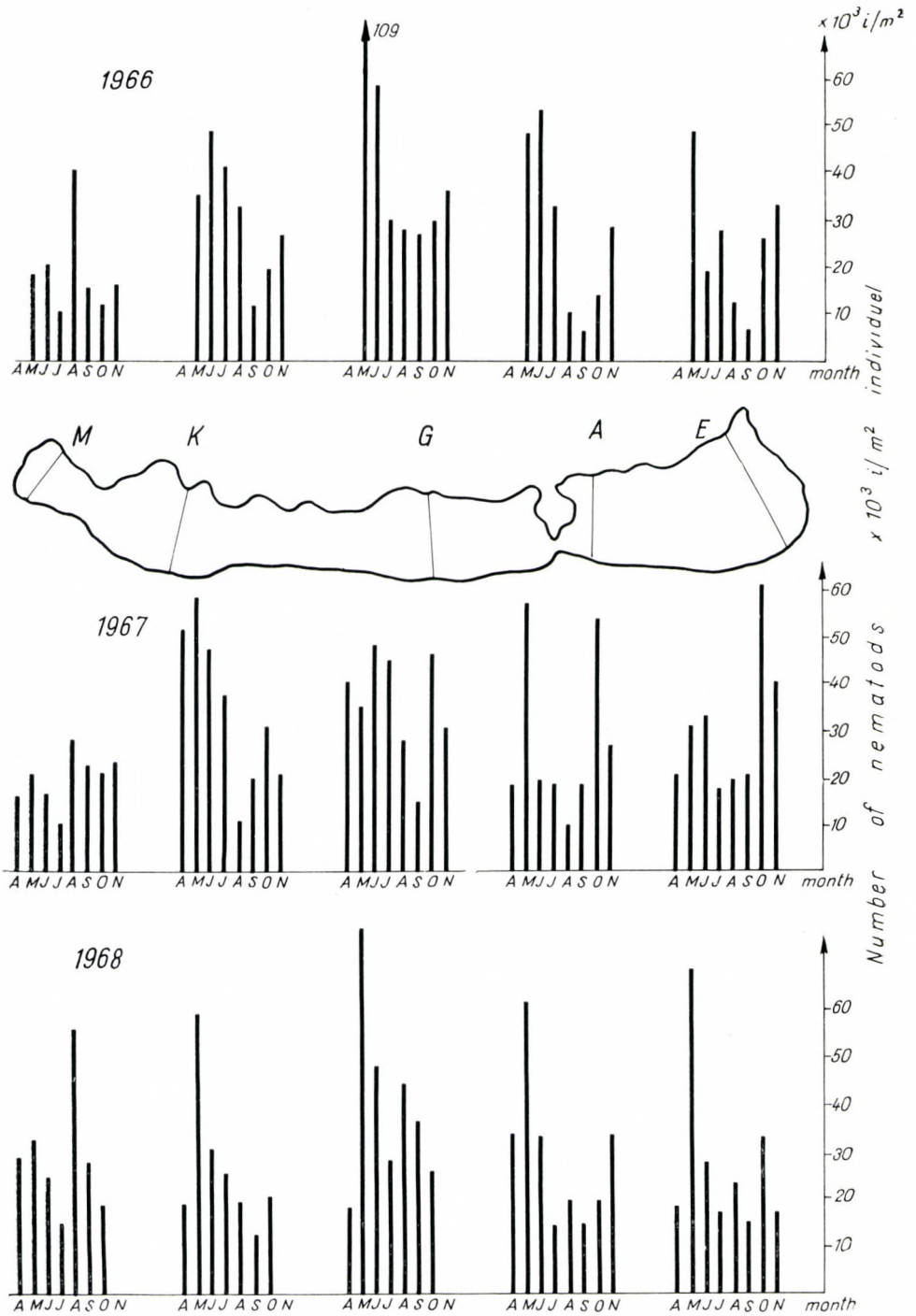

Fig. 5. The number of nematodes in the five transversal sections of Lake Balaton during 1966—68 in number of individuals per m² (i/m²). Each date represents the average of three points (e.g. M_1M_a and M_2) of each section

In the area of Szigliget Bay ("K") the average number of nematodes was 30—40 000 i/m² during all the three years. The number of individuals was the highest in early summer (55—60 000 i/m²), and it charply fell by the late summer down to 11 000 i/m² (second column of *Fig. 5)*. In the average of three years, the most frequently occurring Nematoda was *Theristus setosus* during the cold and *Paraplectonema pedunculatum* during the warm period. Among the less frequent species, *Tripyla glomerans* was found only sporadically in the Keszthely-Bay ("M"), whereas in the regions of Szigliget and Balatonszemes ("K" and "G") it was more frequently observed. A low number of individuals *Aphanolaimus aquaticus* and *Ethmolaimus pratensis* lives in the Szigliget-Bay but they were somewhat more frequent in the region of Balatonszemes, whereas they were completely absent in the Keszthely-Bay.

In the section "G" of the south-western basin the highest number of nematodes (above 100 000 i/m²) was observed during the spring season, caused mainly by the intense propagation of *Monhystera paludicola*, *Ironus tenuicaudatus* and *Paraphanolaimus behningi*. In late summer the lowest number of individuals was observed (20 000 i/m²). During the other periods of the year, the actual frequency of nematodes is roughly the same around 30 000 i/m² (third column of *Fig. 5)*. During the cold period, *Paraphanolaimus behningi* showed the highest numbers here, whereas at the other regions of the south-western basin the species *Theristus setosus* was the most frequent species. During the warm periods, mainly *Paraplectonema pedunculatum* was found in the sections "M" and "K", whereas in section "G" the *Paraphanolaimus behningi* was more frequent. Among the rarer species, *Punctodora ratzeburgensis* and *Monhystera vulgaris* were observed. The Monhysteridae proved to be the richest family here both in the number of species and individuals.

Two regions of the north-eastern basin were investigated: between Balatonfüred and Zamárdi ("A") and between Balatonalmádi and Balatonvilágos ("E").

In section "A" near the peninsula Tihany the amounts of nematodes were of an average of 60 000 i/m² in spring, 20 000 i/m² in summer and 40 000 i/m² in autumn (fourth column of *Fig. 5)*. In January 1968 the number of individuals was 60 000 i/m² in front of Tihany (point "A_0") consisting of *Theristus setosus* in 60 percent. In February of the same year the total number reached 109 000 i/m². The amount of *Theristus setosus* remained virtually unchanged (60 percent), however, its absolute number increased and the proportion of *Tobrilus* species also reached 20 percent. After thawing, the amount of nematodes decreased to 20 000 i/m². During the cold period, the most frequent Nematoda of this section was *Theristus setosus*, whereas during the warm periodi, were *Paraphanolaimus behningi* and *Ironus tenuicaudatus*. Relatively larger numbers of *Aphanolaimus aquaticus*, *Paraphanolaimus anisitsi* and *Ethmolaimus pratensis* belonging to the rarer species occurred here. *Prismatolaimus dolichorus* and *Hemicycliophora aquatica* were also found at this point living only from the north-eastern basin.

In section "E" (Balatonalmádi—Balatonvilágos) 20—30 000 i/m² was found during spring and early summer of 1966 and 1967, whereas by the spring of 1968 it was more than twice of this number: 70 000 i/m². By the end of summer of 1966 this number decreased to 18 000 i/m², and during summer of 1967 and 1968 it amounted to 20 000 i/m². The autumnal number was 40—60 000 i/m² during all the three years (fifth column of *Fig. 5)*. At this

place, *Theristus setosus* was the most frequent species during the cold while during the warm season, *Ironus tenuicaudatus* was. The highest amounts of *Tobrilus gracilis* and *Tobrilus helveticus* occurred in the area of section "E", especially during the cold period.

It can be stated in general that the number of individuals was higher in spring and autumn than in summer months.

According to the benthic investigations of STANCZYKOWSKA (1966) in Lakes Mikolajskie and Taltowisko, the highest number of nematodes was encountered in autumn: 40 000 i/m², the lowest one did in winter: 6000 i/m², and there was a gradual increase from spring. The water temperature of the Polish lakes may vary maximally around 10—12 °C. This temperature represents the transition of the cold and warm periods in Lake Balaton during spring. According to our results, the number of individuals was higher in Lake Balaton during spring, whereas in the Polish lakes during autumn. It is very likely that not the period but the suitable temperature represent the more important factor for the activity and propagation of nematodes.

The species display a seasonal variation: during the cold period, i.e. below 12 °C, everywhere the *Theristud setosus* was the most frequent species. During the warm period, i.e. above 12 °C, the following species predominated: *Paraplectonema pedunculatum* in the Keszthely-Bay ("M") and Szigliget-Bay ("K"); *Paraphanolaimus behningi* at Balatonszemes ("G"); the latter and partly *Ironus tenuicaudatus* in front of Tihany in the north-eastern basin ("A"); and the last one at Balatonalmádi ("E").

The amounts of the frequent species

Paraplectonema pedunculatum (H.) S. was the most frequent nematoda. Its distribution was rather heterogeneous in the whole area of the lake changing by seasons and even by months: its number varied between 1000 and 25 000 i/m² *(Fig. 6)*. In the north-eastern basin its number showed spring and autumnal maxima (14—16 000 and 7—10 000 i/m², respectively). Just the opposite was observed in the Keszthely-Bay ("M") where the increase of number was significant during summer, reaching 10—25 000 i/m². In the Szigliget-Bay ("K") the number was higher (25 000 i/m²) during summer than during spring and autumn, whereas at Balatonszemes ("G") a reversed state was recorded. Considering the whole lake, this species lived during summer rather more in the south-western basin and during spring and autumn rather more in the north-eastern basin. Generally its number decreased to a minimum (1000—5000 i/m²) by the early autumn and increased again by the late autumn (10 000 i/m²), then with the decrease of the water temperature it decreased again. Under the ice only 1—2000 i/m² were found.

The quantity of *Paraphanolaimus behningi* M. showed two maxima per year *(Fig. 7)*. In early spring low number was observed (3000 i/m²), and as soon as the water temperature rose above 10—12° C, it abruptly propagated to reach 10 000 i/m². During summer this number somewhat lowered (5000 i/m²), during autumn increased (15 000 i/m²) and by late autumn hardly a few thousand were present. During winter only a small number lives under the ice. It was collected always in low numbers in the Keszthely-Bay ("M") (2—5000 i/m²), it was the most frequent in the sections "K" and "G" (8—12 000 i/m²), whereas in the north-eastern basin moderate quantities of roughly identical

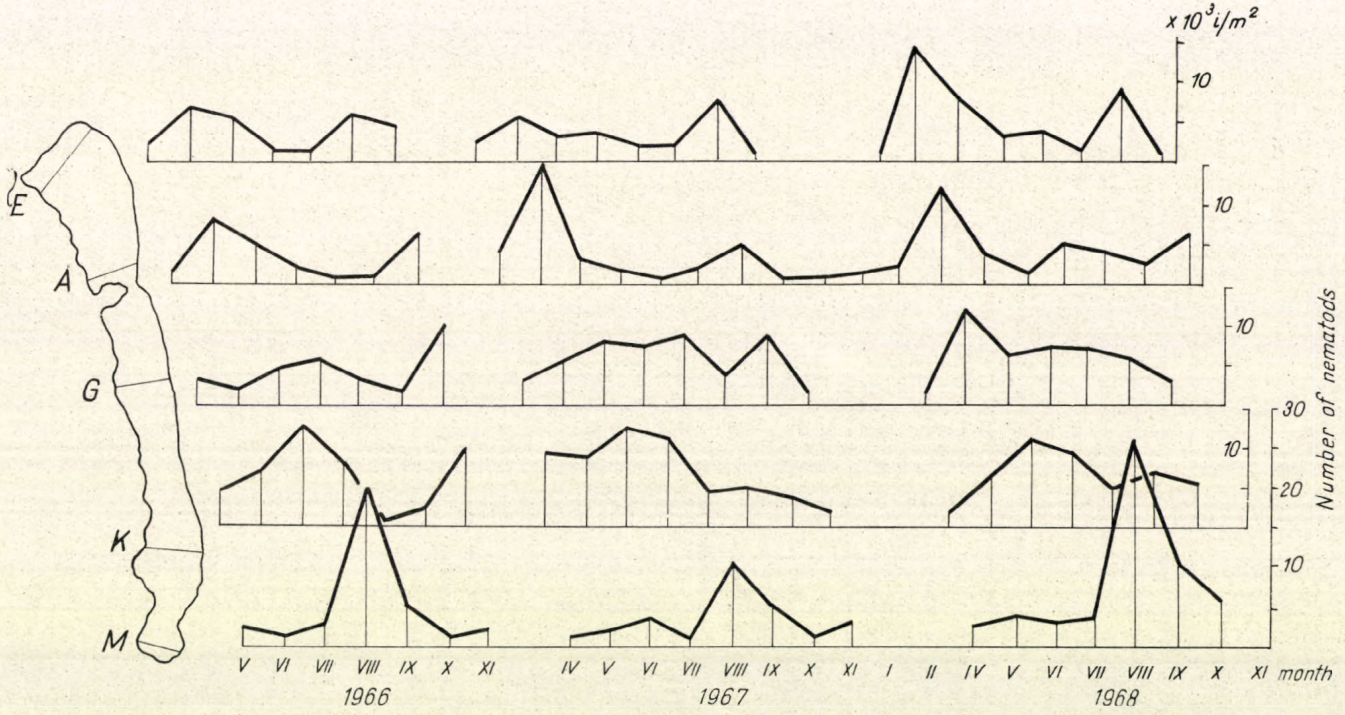

Fig. 6. Paraplectonema pedunculatum (H.) S. The change in the number of individuals in the five transversal sections of Lake Balaton during 1966—68. Each date represents the average of three points of each segment

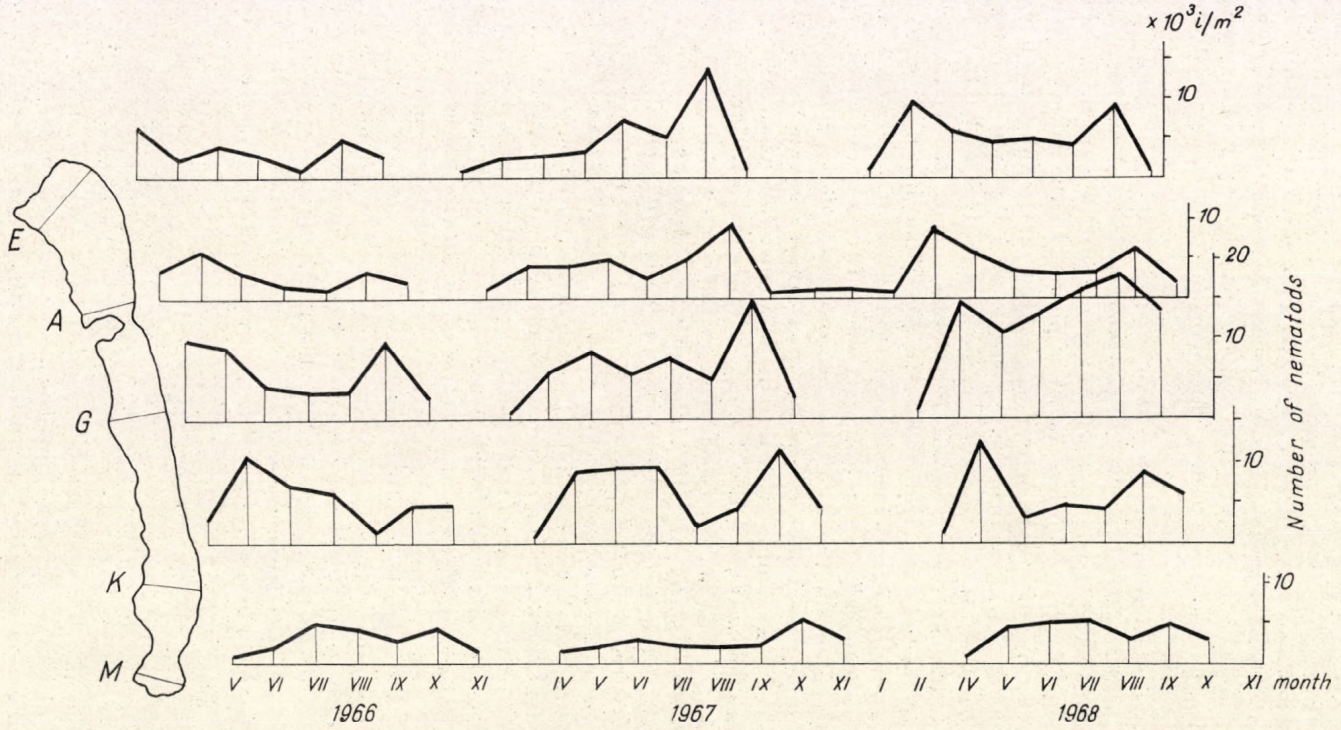

Fig. 7. The monthly change in the number of individuals of *Paraphanolaimus behningi* M. in the five transversal sections of Lake Balaton during 1966—68. Each date represents the average of three points of each segment

distribution were found. The change in the number of individuals showed a maximum in the autumn of 1967 as well as a spring and an autumnal maxima in 1966 and 1968 in the north-eastern basin. At Balatonszemes ("G") there was rather an autumnal maximum, but at Szigliget ("K") a spring one was observed. In the Keszthely-Bay ("M") its amount was identical and varied practically at the same level.

The highest number of *Ironus tenuicaudatus* dM. was found in the centre of the lake in the spring of 1966 at Balatonszemes ("G") reaching 15—25 000 i/m² *(Fig. 8)*. In the spring of 1967 and 1968 only 10 000 i/m² were observed at the same place and even less at other places. In the middle of summer it was present in 5—8000 i/m² in the whole area of the lake, no increase was observed during autumn either. Generally one can state that the highest number of *Ironus*, 10 000 i/m² in average occurred in Lake Balaton during the autumn, this number gradually decreased during the year, nevertheless it could be collected even from under the ice (1000 i/m²).

Theristus setosus B. definitely prefers cold water *(Fig. 9)*. It was found to be frequent especially in the samples collected from under the ice, representing 50—60 percent of the total number of nematodes reaching 55 000 i/m². During summer its number decreased to a minimum value of 1—3000 i/m², at some places it was completely absent in August. The change in the number of individuals showed the same tendency during all the three years. It was more frequent in the north-eastern than in the other basin.

Monhystera paludicola dM., similarly to *Theristus setosus*, was found in higher amounts in spring and autumn *(Fig. 10)*. During winter under the ice it occurred in 15 000 i/m² not reaching the number of *Theristus setosus*. Its number was 4—6000 i/m² during early spring, it increased to 15 000 i/m² by May and at Balatonszemes ("G") it reached even 65 000 i/m² in 1966. But it decreased to 2000 i/m² or at some places even to 0, especially in 1967, as soon as the prolonged warm period appeared. It propagated again during autumn, at early winter it already showed 5000 i/m². It was frequent everywhere in the spring of 1966 and 1967 except at the Keszthely-Bay ("M"), it displayed a uniform distribution in summer and autumn during all the three years, although its number was low.

Tobrilus gracilis B. was found in the samples representing hardly 3 percent of all the nematodes. Its number was negligibly in summer, whereas during the cold season it reached 2—3000 i/m², and was even more frequent in samples collected from under the ice. More individuals were collected in the north-eastern basin ("A" and "E") as well as in the Keszthely-Bay ("M") than in the other regions of the lake.

The biomass and its changes

The biomass is roughly proportional to the number of individuals present in the samples. When calculating the biomass, first the average weights of the species were determined according to ANDRÁSSY (1956). The weight of the animals (G) was calculated with the following equation

$$G = \frac{a^2 \times b}{1\,600\,000},$$

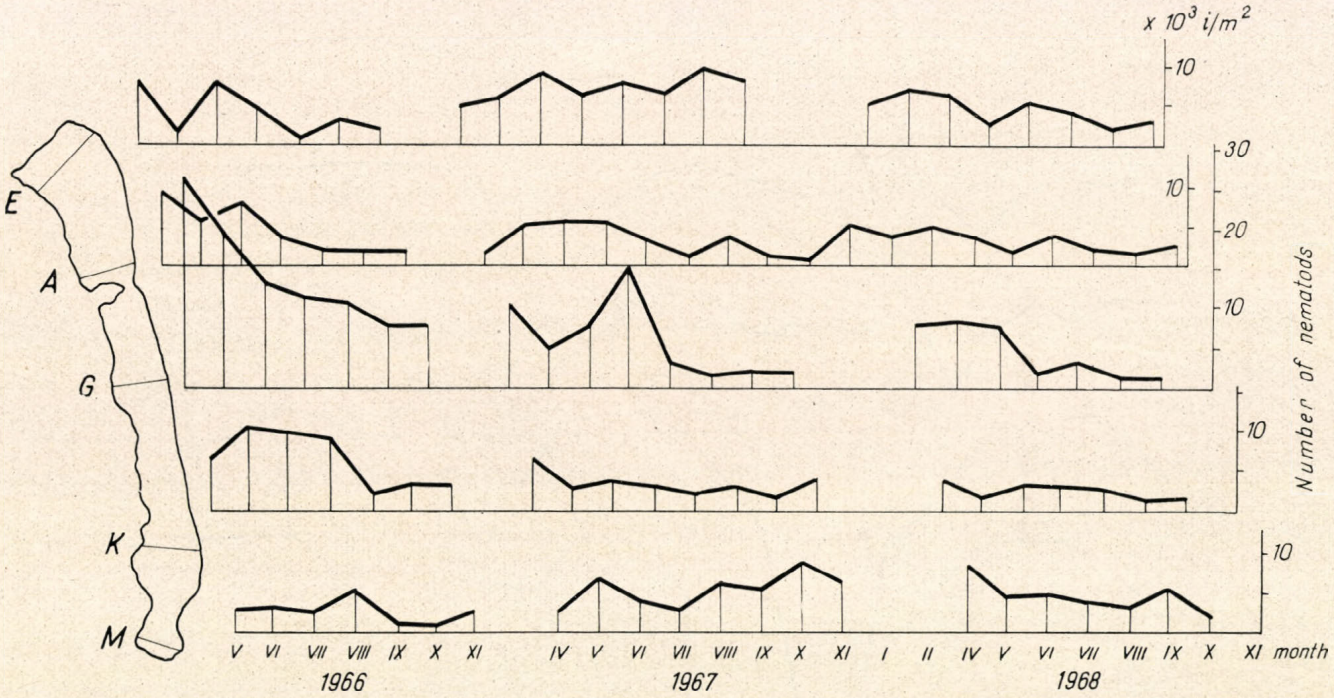

Fig. 8. The monthly change in the number of individuals of *Ironus tenuicaudatus* in the five transversal sections of Lake Balaton during 1966—68. Each date represents the average of three points of each section

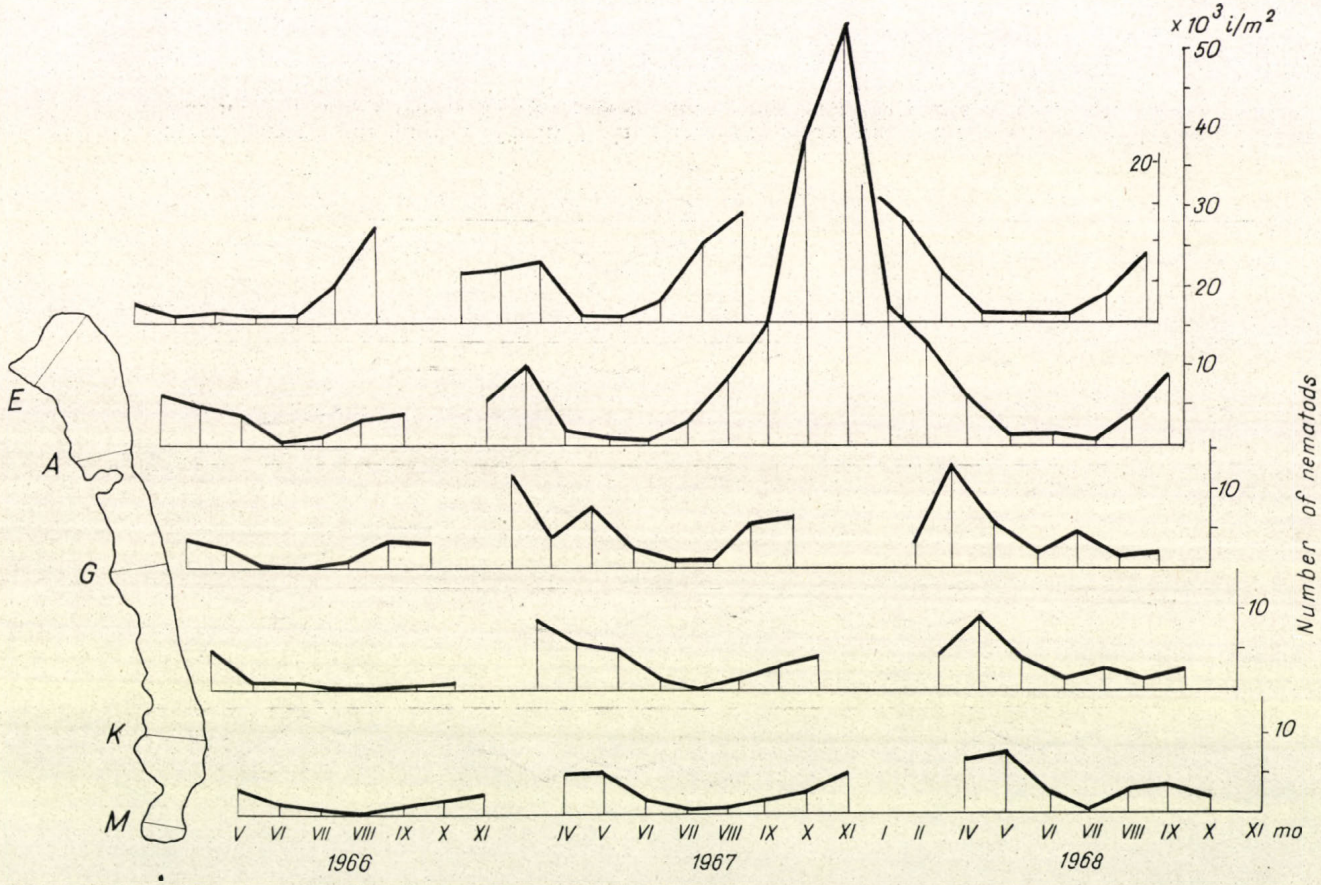

Fig. 9. The monthly change in the number of individuals of *Theristus setosus* (B.) F. in the five transversal sections of Lake Balaton during 1966—68. Each date represents the average of three points of each section

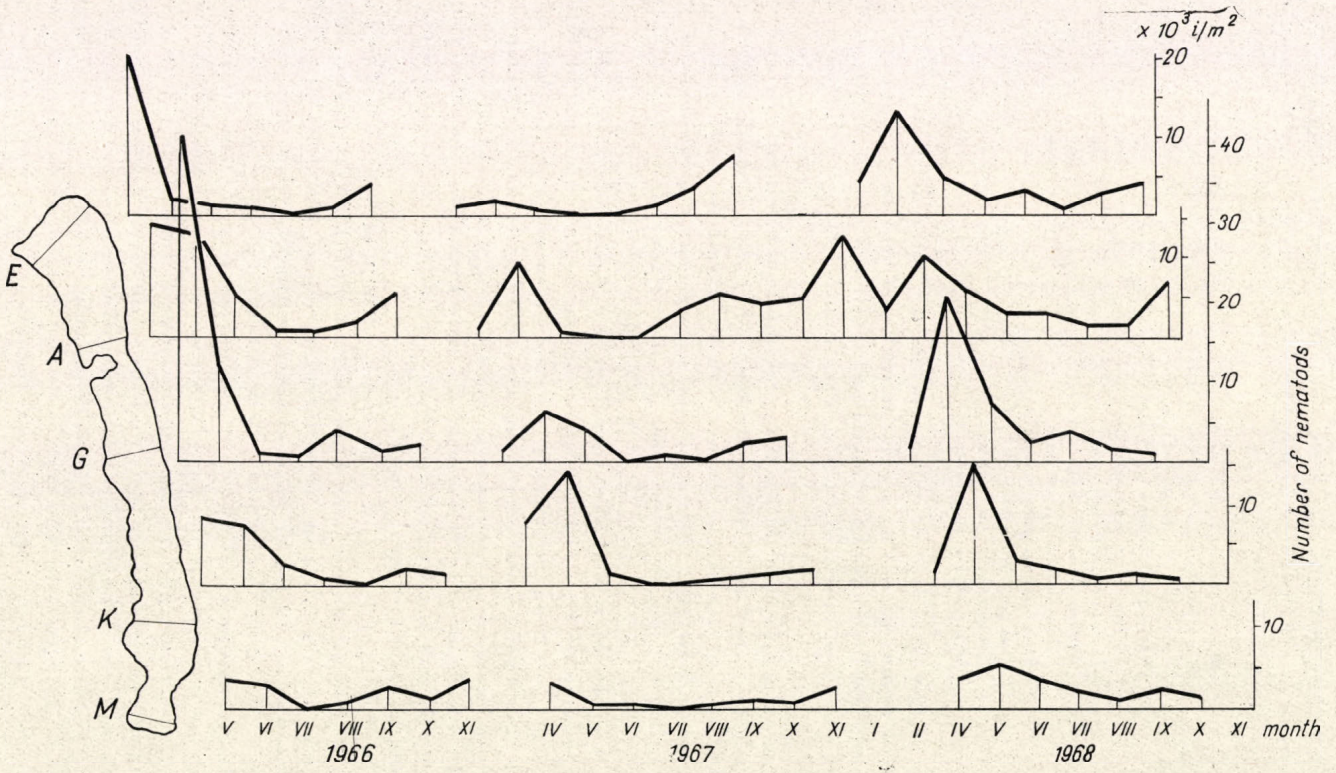

Fig. 10. The monthly change in the number of individuals of *Monhystera paludicola* dM. in the five transversal sections of Lake Balaton during 1966—68. Each data represents the average of three points of each section

where a is the largest diameter of the body and b is the length of the body, both in microns, and G is in μg units. The weihgt of the most frequent nematodes reached 1 μg only rarely:

Ironus tenuicaudatus	1.26 μg
Paraplectonema pedunculatum	0.06 μg
Paraphanolaimus behningi	0.08 μg
Theristus setosus	0.10 μg
Monhystera paludicola	0.07 μg
Tobrilus gracilis	0.76 μg
Aphanolaimus aquaticus	0.05 μg
Ethmolaimus pratensis	0.09 μg
Monhystera macramphis	0.08 μg
Tripyla glomerans	0.91 μg
Dorylaimus stagnalis	2.49 μg
Monhystera stagnalis	0.05 μg

Four of the five most frequent species do not reach even 0.1 μg, only the weight of *Ironus* is to 1.2 μg. The weight of *Dorylaimus stagnalis* (2.5 μg) could increase the biomass of the lake to a significant extent, however, it lives in the open-water sediment in such a small number that it effect is undetectable.

The μg values were multiplied by the number of individuals and at each species were calculated for 1 m^2 separatedly *(Fig. 13)*. Considering the whole lake, the biomass of nematodes varies between 4 and 20 mg/m^2. This value is nearly twice as high (16—20 mg/m^2) in spring than in summer the lowest value (4—6 mg/m^2) usually was observed in early autumn then it increased slowly.

The biomass of nematodes varied in the Keszthely-Bay ("M") during 1966 (first column of *Fig. 11)*. In August it reached a maximum of 13 mg/m^2, then decreased to 2 mg/m^2 during autumn, representing the lowest value which had ever been observed during the investigations. The tendencies in the change of biomass were identical even during 1967 and 1968. From the level of 14—16 mg/m^2 observed in spring, it decreased by the end of summer to 5—8 mg/m^2, increased again to 14—15 mg/m^2 during early autumn and dropped again within several months.

In the Szigliget-Bay ("K") (second column of *Fig. 11)* the biomass value was 20 mg/m^2 during the whole summer of 1966, it decreased below 6 mg/m^2 only during autumn then increased again. In 1967 and 1968 the spring value was 8—10 mg/m^2, it decreased gradually below 4 mg/m^2 and remained at 4—6 mg/m^2 during the whole autumn.

At Balatonszemes ("G") (third column of *Fig. 11)* an extreme value of 40 mg/m^2 was observed in May 1966 caused by the mass appearance of *Monhystera paludicola* and *Ironus tenuicaudatus*. Such high values were not obtained in 1967, although a high number of nematodes was present in the early spring samples. The changes of biomass values displayed a similar tendency during all the three years. The spring value of 21—40 mg/m^2 decreased to its half or third parts by the early autumn then increased again by winter.

Samples could be taken in every periods of the year from the section "A" between Balatonfüred and Zamárdi. The changes in the number of individuals and the biomass showed two maxima during one year: the first one in to February under the ice, the second one appeared in May. According to the observations, the biomass was nearly one third higher under the ice

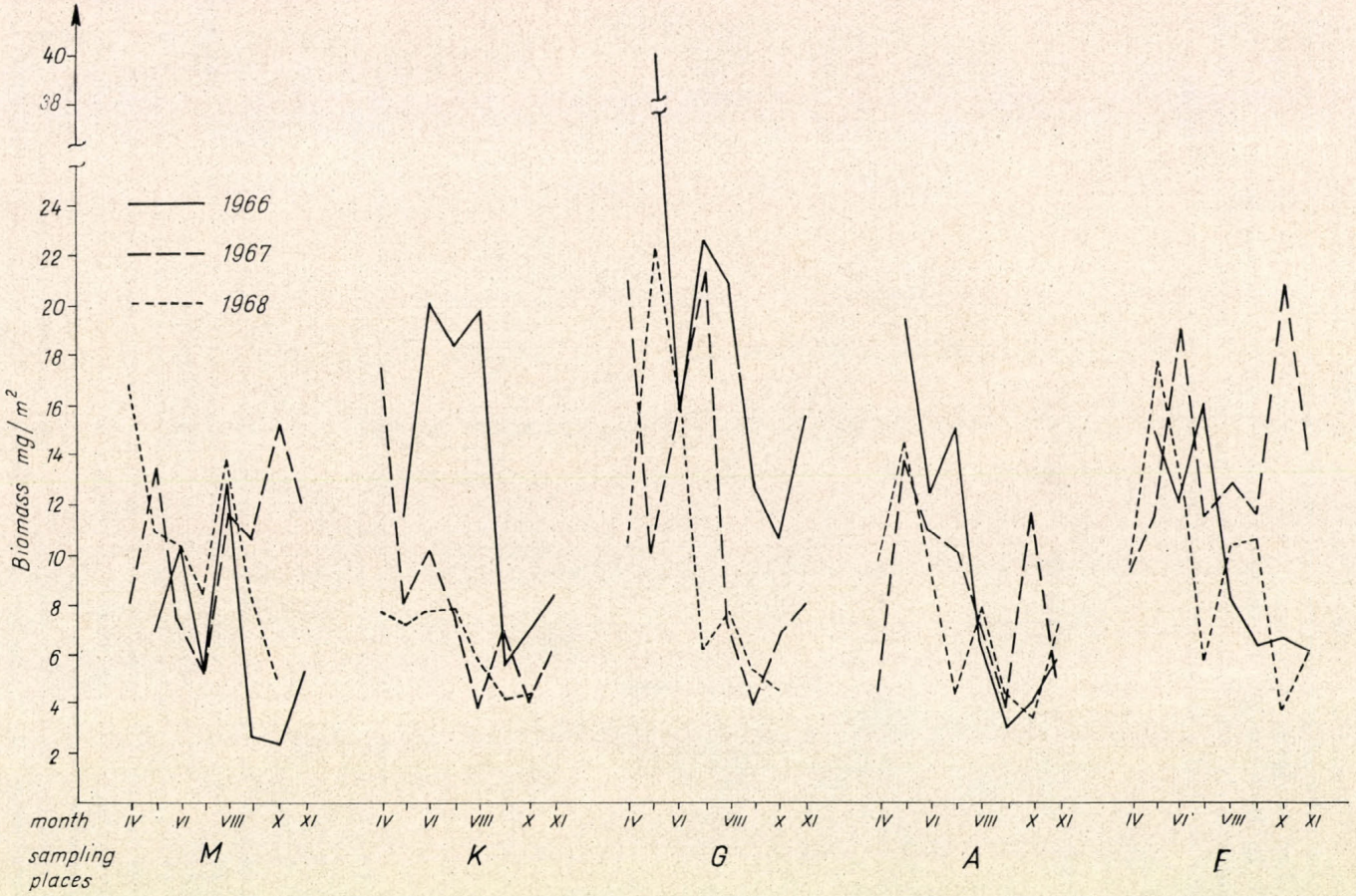

Fig. 11. The monthly change of nematoda biomass in the five transversal sections of Lake Balaton during 1966—68. Each date represents the average of three points of each section

(24 mg/m²) than the value of May (16 mg/m²), and about six-times higher than the value of late summer (4 mg/m²) (fourth columns of *Fig. 11* and *12)*.

The analysis of biomass values was not so simple at Balatonalmádi ("E"). In 1966 the general tendency was similar to that observed in the other regions, namely, the higher biomass value, 16—17 mg/m², of spring and early summer reached a minimum by the early autumn (4—6 mg/m²). On the other

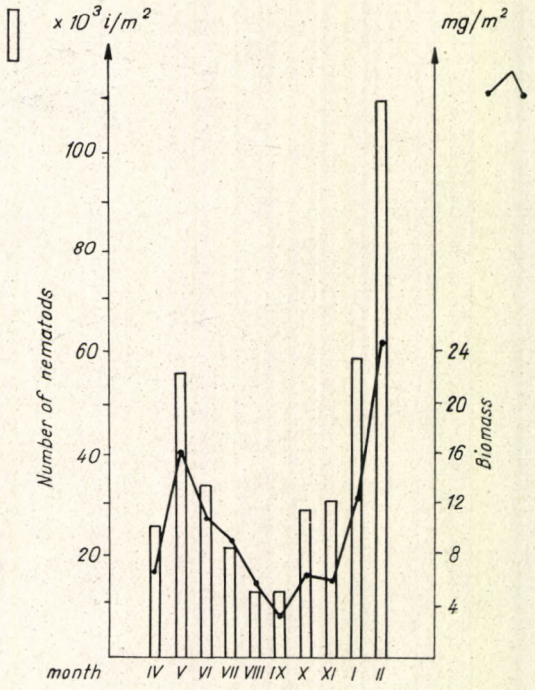

Fig. 12. The change in the number (i/m²) and biomass of nematodes at the point "A_0" at Tihany in the section Balatonfüred—Zamárdi in the average of three years

hand, in 1968 two maxima were observed, one in June (19 mg/m²) and an other in October (21 mg/m²), whereas in the other months of the year the biomass was nearly identical, about 12 mg/m² (fifth column of *Fig. 11)*.

The yearly change of the nematode biomass has been estimated. The biomass values of months, species, sections were considered at that estimation in the average of three years. According to the calculations, the biomass of nematodes amounts to 13 mg/m² at early spring in the western and 9 mg/m² in the eastern basin of the lake. In the north-eastern basin and east to it up to Balatonszemes ("G"), the biomass increases to 16—20 mg/m² during May and after that period there is a gradual decrease over the whole area of the lake to 6—8 mg/m² until the end of September, however, parallel with the cooling down of temperature, a reincrease can again be observed *(Fig. 13)*.

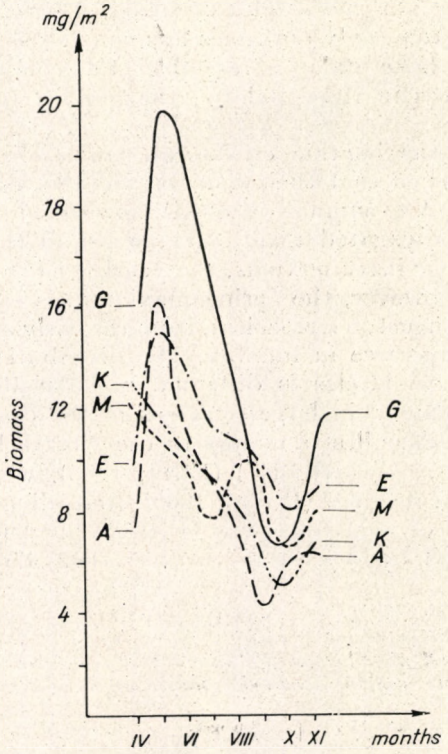

Fig. 13. The change of nematoda biomass in the five sections of Lake Balaton in the average of three years

Discussion

SCHIEMER (1969) reported on the nematoda fauna of Lake Fertő (Neusiedler See). That lake is similar to Lake Balaton in so far as it is shallow, with a flattened bottom having a sediment mixed with detritus and water of about pH 8. One part of the species found there occurred even in Lake Balaton. The most frequent ones are: *Paraplectonema pedunculatum* (about 70 percent), *Tobrilus gracilis* (about 15 percent) and *Monhystera paludicola* (about 5 percent). SCHIEMER disclosed a relation between the quality of sediment and the distribution of species, namely the *Paraplectonema pedunculatum* did not prefer the detritic mud of 5—10 cm thickness and neither did the roughly granulated sand. The occurrence of this species in Lake Balaton further supports that observation. In the Keszthely-Bay ("M") where the sediment particles of less than 2 μ size represent 25—30 percent (MÜLLER, 1969), much more *Paraplectonema pedunculatum* occurred during summer than in the Szigliget-Bay ("K") where 40 percent and than at the sandy shore of south where 10—15 percent was the proportion of sediment particles of less than 2 μ size. In Lake Fertő SCHIEMER described to be directly proportional the number of individuals of *Tobrilus gracilis* and *Monhystera paludicola* to the thickness of mud. This could not be observed in Lake Balaton. In the soft mud of

Lake Fertő 10^5—10^6 i/m² nematodes occurred, whereas in the places having a more compact bottom, only ten times less nematodes were found. The open-water sediment of Lake Balaton resembles the compact sediment of Lake Fertő. At such places in Lake Balaton the number of nematodes was 10—20 000 i/m².

Investigating the benthic crustacean fauna of Lake Balaton, PONYI (1966; 1969) established that their number was the highest at early summer (June), the lowest at late summer (August), however, by early winter (November) the crustacea propagated again reaching almost the values of early summer. According to our investigations, the yearly change of nematodes follows also that rhythm, however, the spring maximum is earlier, already in May, the minimum is in August, nevertheless, from the early autumn till the thawing of ice, there is an increase in number. The distribution of small crabs, the Chironomidae and nematodes is different in Lake Balaton. The larvae of Chironomidae were found in largest masses in the centre of the lake ("G") in May 1965, and in smallest amounts in the Keszthely-Bay ("M") and the north-eastern basin ("A" and "E") (ENTZ, 1965), whereas the distribution of Crustacea was just reversed (PONYI, 1969). According to the present results, the highest number of nematodes was in the central part of the lake ("G") during 1966—68 and the lowest in the Keszthely-Bay ("M") *(Table III)*.

TABLE III

The amount and distribution of "microcrustacea", larvae of Chironomus plumosus MEIG. *as well as nematodes living in the sediment of Lake Balaton*

	Keszthely "M"	Szigliget "K"	B. Szemes "G"	Tihany "A"	Fűzfő "E"
	i/m²				
"Microcrustacea" (PONYI, 1969)	14 800	4 300	11 800	14 800	15 800
Larvae of Chironomus plumosus (ENTZ, 1965)	24	148	356	5	5
Nematoda 1966—68 average	23 000	31 000	44 000	28 000	28 000

It became clear on the basis of investigations of the benthic animals that the open-water sediment of a great extent, i.e. Lake Balaton can be divided into three large parts:

1. North-eastern basin ("A" and "E").
2. Keszthely-Bay ("M").
3. Transitional regions between the former two ("K" and "G").

The Szigliget-Bay is mainly of outstanding character, however, often resembles the Keszthely-Bay. In the central part of Lake Balaton, in the region of section "G" predominate the properties of the north-eastern basin, nevertheless often some altered characteristics are realized.

Summary

In the open-water sediment of Lake Balaton the following nematodes predominated during 1966—68: *Paraplectonema pedunculatum* S. (20 percent), *Paraphanolaimus behningi* M. (20 percent), *Ironus tenuicaudatus* dM. (19 percent), *Theristus setosus* (B.) M. (17 percent), *Monhystera paludicola* dM. 15 percent), Their occurrence varies by seasons: during winter (between 4 and 12 °C) *T. setosus* and *M. paludicola* are the most frequent species, while during summer they are absent at some places. A rare species, *Paraphanolaimus anisitsi* (D.) ANDRÁSSY 1968 was also observed in the sediment of the lake.

The highest number of nematodes was found in spring (May), 60—80 000 i/m², there was a gradual decrease during summer 10—20 000 i/m², then from the middle of autumn (October) there was an increase again. During winter 100 000 i/m² nematodes were observed under the ice at Tihany ("A_0").

The regional distribution of nematodes was also variable: the highest number was at Balatonszemes ("G") averaging 44 000 i/m², the lowest one in the Keszthely-Bay ("M") averaging 23 000 i/m².

The biomass of nematodes varied between 4—20 mg/m². Generally this value is nearly twice as high in spring than in summer, it is the lowest usually in early autumn (4—6 mg/m²) and then slowly increases. The highest value of biomass was found at Balatonszemes ("G").

On the basis of the benthic fauna, the Lake Balaton can be divided into three regions: the north-eastern basin ("A" and "E"), the Keszthely-Bay ("M") and the central part of the lake ("K" and "G").

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A BALATON NEMATÓDÁI.
IV. A FAUNA ÉVSZAKOS VÁLTOZÁSA

Biró Kálmán

Összefoglalás

A Balaton nyíltvízi üledékében 1966—68-ban a *Paraplectonema pedunculatum*, *Paraphanolaimus behningi*, *Ironus tenuicaudatus*, *Theristus setosus* és *Monhystera paludicola* a leggyakoribb fonálféreg *(2. táblázat)*. Évszakonként az egyes fajok mennyisége változik: télen (+4 és +12 C° vízhőmérséklet között) és a jég alatt *Theristus setosus* és *Monhystera paludicola* a leggyakoribb, de ezek nyáron hiányozhatnak is.

A fonálférgek mennyisége a tó különböző területein változó *(5. ábra)*. A legtöbb tavasszal (május) 60—80 000 i/m², a nyár folyamán fokozatos csökkenés következett (10—20 000 i/m²), majd az ősz közepétől (október) ismét számbeli növekedés volt (20—30 000 i/m²). Télen a jég alatt Tihanynál („A_0") 100 000 i/m² mennyiséget észleltem. Legtöbb fonálféreg B.-szemesnél („G"), átlag 44 000 i/m², legkevesebb a Keszthelyi öbölben („M"), átlag 23 000 i/m² volt.

Három éven keresztül a tó különböző területein megfigyeltem a leggyakoribb fajok egyedszám változását *(6., 7., 8., 9., 10. ábrák)*.

A fonálféreg biomassza 4—20 mg/m² között változott. Tavasszal közel kétszer akkora (16—20 mg/m²) ez az érték, mint nyáron, ősz elején volt a legkisebb (4—6 mg/m²) és ezután lassú emelkedést tapasztaltam *(11. ábra)*. A legtöbb biomasszát B.-szemesnél („G") mértem.

Tihany előtt („A_0") februárban a jég alatt a biomassza (és egyedszám) csaknem kétszerese a tavaszi (május) értéknek és hatszorosa a nyári (szeptember) minimumnak *(12. ábra.)*

A Keszthelyi („M") és a Szigligeti öbölben („K") a koratavaszi (április) biomassza maximumtól fokozatos csökkenés figyelhető meg az ősz végéig (október) 12 mg/m²-ről 6 mg/m²-re, addig B.-szemestől Fűzfőig („G", „A", „E") áprilisi alacsony biomassza májusban majdnem megduplázódik, és csak ez után következik a biomassza fokozatos csökkenése az őszvégi minimumra és a víz lehűltével mindenütt fokozatosan emelkedik *(13. ábra.)*

Az üledékfauna alapján a Balaton 3 területre tagolható: ÉK-i medence („A" és „E"), Keszthelyi öböl („M") és a tó középső része („K" és „G").